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Aquiring the skills and knowledge associated with science, technology, engineering and mathematics (disciplines collectively known as STEM) is increasingly important preparation for life and work in the 21st century. Yet education assessments suggest that American students are not adequately prepared for STEM careers. What's more, interest in these fields appears to be declining even as demand for STEM-capable employees increases. A lack of engagement in STEM narrows students' future career options and limits their decision-making capacity as citizens and consumers.

Although no single institution can dramatically alter these trends, out-of-school time programs such as 21st Century Community Learning Centers (21st CCLC) offer the potential to increase student interest and expertise in STEM. Compared with the regular school day, such programs offer students more informal learning environments with extended time for exploration. These conditions are conducive to offering high-interest, high-quality STEM activities that can complement or supplement more formal academic studies.

This research brief examines the literature on STEM education in out-of-school settings. It concludes with a discussion of the challenges to providing students with expanded opportunities to deepen their interest and expertise in these critical disciplines through out-of-school time learning experiences.

A Double Bind: Low Achievement and Low Interest in STEM

American students are lagging in their academic performance in math and science. The 2007 ACT College Readiness Report points out that only 43 percent of graduating seniors are ready for college math and just 27 percent are ready for college science. In 2005, only 29 percent of fourth- and eighth-grade students and only 18 percent of 12th- grade students performed at the Proficient level on the National Assessment of Educational Progress (Grigg et al., 2006).

There is also an apparent "interest gap" when it comes to STEM-related fields. The President's Council of Advisors on Science and Technology points to evidence suggesting that "many of the most proficient students, including minority students and women, have been gravitating away from science and engineering toward other professions" (2010, p. 2). According to Public Agenda's Reality Check 2006, approximately 45 percent of students would be "really unhappy if [they] ended up in a job or career that required doing a lot of math and science" (p. 10). Students also state that the science and math taught in school have little to do with their lives outside school (Bouillion & Gomez, 2001; Zacharia & Calabrese Barton, 2003).

The Out-of-School Time Opportunity

Students spend twice as many waking hours outside of school as in it. Out-of-school time programs offer the potential to supplement learning from the school day and to provide targeted assistance to students who need help beyond what they can receive in the classroom, according to Structuring Out-of-School Time to Improve Academic Achievement (Beckett et al., 2009), a

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research-based practice guide from the What Works Clearinghouse. The guide states that academically oriented out-of-school experiences offer promise to close the achievement gap; however, such experiences must be carefully orchestrated to engage students and facilitate learning. Coordinating out-of-school time programs with the learning activities of the regular school day leads to a shared mission of improving academic performance.

Out-of-school time programs afford a special opportunity to expand science learning experiences for millions of children, according to Learning Science in Informal Environments, a report from the National Research Council. Out-of-school programs that emphasize science "can make important contributions to students' understanding of scientific and mathematical concepts, their ability to think scientifically, and their use of scientific language and tools. They also can be effective in improving students' attitudes toward science and toward themselves as science learners" (National Research Council, 2009, p. 294).

Effective out-of-school time programs incorporate key principles of informal learning. According to Surrounded by Science (Fenichel & Schweingruber, 2010, p. 5), effective informal learning environments:

— Engage participants in multiple ways, including physically, emotionally and cognitively.

— Encourage participants to have direct or media- facilitated interactions with phenomena of the natural world and the designed physical world in ways that are largely determined by the learner.

— Provide multifaceted and dynamic portrayals of science.

— Build on the learner's prior knowledge and interest.

— Allow participants considerable choice and control over whether and how they engage and learn.

Increasing STEM opportunities for students in out- of-school settings is one of the key recommendations of the President's Council of Advisors on Science and Technology. The Council concludes that "students need opportunities to establish deeper engagement with and to learn science and mathematics in non- standard, personal, and team-oriented ways that extend beyond the curriculum and the classroom. This is especially vital for identifying and nurturing high achievers and future STEM innovators" (2010, pp. 7-8).

Some 8.4 million children in the United States regularly participate in afterschool programs, and such programs offer a unique opportunity to engage children in hands-on, experiential science learning. "Programs can meet their youth development goals by getting kids excited by science. Many education leaders recognize the potential of these programs to combine cognitive, social and emotional development in ways consistent with the best advice from learning research" (The After-School Corporation, 2010, p. 2).

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Out-of-school time programs also offer promise to increase interest in STEM among populations currently underrepresented in scientific and technical fields. African Americans, Native Americans and Hispanics make up 28.5 percent of the U.S. population, yet they represent only 9.1 percent of college-educated Americans in the science and engineering workforce (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline et al., 2010).

Although math, science and engineering fields were once dominated by males, the gender gap is closing. Women now earn early nearly half the bachelor's degrees in math. Still, women continue to be under- represented in math, science and engineering-related careers. Overall, more women than men graduate from college with a bachelor's degree; however, men earn a higher proportion of degrees in many science and engineering fields of study (National Science Foundation, 2011). Women's participation in STEM-related college majors is lowest in the fields of engineering and computer sciences, according to National Science Foundation data.

Out-of-school time programs that focus on girls' involvement in STEM can play an essential role in improving female representation in these traditionally male-dominated fields, according to the Harvard Family Research Project. A research update from the project states that out-of-school time programs offer girls a nonthreatening and nonacademic environment for hands-on learning that is collaborative, informal and personal (Chun & Harris, 2011).

STEM in Out-of-School Settings

A common goal of afterschool programming is to offer students activities that are simultaneously fun and academically enriching. According to a review of high-functioning afterschool programs (Huang et al., 2010), a number of strategies promote academic and social learning. These include cross-content integration, diversity of activities, real-world examples, dialogic and cooperative learning, culturally significant programming, special consideration for the students' activity preferences, and the incorporation of enrichment and recreational activities. To facilitate learning, motivation and engagement across academic areas, including science and math, high-quality afterschool programs do the following:

— Make learning fun.

— Offer diverse activities.

— Use real-world and relevant examples.

— Use field trips, student performances and exhibitions to advance learning.

According to Huang and colleague, additional insights about quality programs come from the Afterschool Training Toolkit, a product of the National Partnership for Quality Afterschool

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Learning. As part of the product development process, research teams reviewed literature and conducted observations in 53 afterschool programs to determine best practices for supporting academic instruction in specific disciplines, including math, science and technology. Following are their research- based guidelines for encouraging high-quality afterschool programming in each of these disciplines.

Science: Afterschool offers a particularly appropriate venue for inquiry learning about science. With longer blocks of time and more flexibility than in regular classrooms, students can explore science concepts more deeply during out-of-school learning. Researchers (Falkenberg, McClure, & McComb, 2006) found that quality science activities in afterschool settings engage students in these activities:

— Investigating science through inquiry.

— Exploring science through problem- and project- based learning.

— Integrating science with other content areas.

— Tutoring in science for content and skill development.

— Learning with families and using community resources.

Math: Practices that support students' social, emotional and physical development provide the relevant link between successful afterschool programming and effective instruction in mathematics. Briggs-Hale et al. (2006) found that quality math activities in afterschool settings have the following characteristics:

— Encourage problem solving. Help students pursue solutions to intriguing problems using what they know about mathematics facts, skills and strategies, and encourage students to ask questions and use thinking skills.

— Develop and support "math talk." Encourage students to use language to express their ideas, build on ideas together, and share strategies and solutions.

— Emphasize working together. Encourage students to discuss concepts, compare ideas, justify methods and articulate thinking so that they gain awareness of the different strategies individuals apply to problem solving.

Technology: Using technology regularly in afterschool programs to support learning leads to improved motivation, attitudes and academic achievement (Huang et al., 2010). Quality technology activities in afterschool settings help students with the following (Heath, 2007):

— Developing self-expression and creativity.

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— Gathering and sharing information.

— Finding and solving problems.

— Living and working with technology.

— Learning in virtual spaces.

— Building skills and understanding.

Engineering: Introducing engineering concepts to K-12 students during out-of-school programs is a relatively new approach and does not yet offer a research base comparable to those of math, science and technology. However, findings are emerging about promising programs that engage students in engineering or design challenges.

Design It! Engineering in After School Programs (Design It!) is a program that challenges students to build working models of small, functional toys and machines as an introduction to engineering concepts. Design It! was developed as a collaboration project between six urban science centers and more than 30 community-based afterschool programs. According to a report about lessons learned from the Design It! pilot, these hands-on, inquiry-based activities "offer a context for children to develop basic skills, general problem-solving strategies, and social development, which is applicable to their performance in school as well as their later involvement in the working world" (Coltin & Gannett, 2002, p. 9).

FIRST robotics programs challenge student teams to construct and program robots for competitions. Professional engineers typically provide mentoring and technical assistance. A survey of competition participants (Center for Youth and Communities, Brandeis University, 2005) found that, compared to non-FIRST students with similar backgrounds and academic experiences, FIRST participants exhibited these benefits:

— More than three times as likely to major specifically in engineering.

— Roughly 10 times as likely to have had an apprenticeship, internship or co-op job in their freshman year.

— Significantly more likely to expect to achieve a postgraduate degree.

— More than twice as likely to expect to pursue a career in science and technology.

— Nearly four times as likely to expect to pursue a career specifically in engineering.

— More than twice as likely to volunteer in their communities.

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Challenges and Implications

Many out-of-school providers already recognize the value of STEM programming to help students increase academic achievement. More than 90 percent of 21st CCLC programs offer some STEM activities, affording more time for young people to engage in science and math activities after school (Learning Point Associates, 2006). Despite the promise of promoting STEM education during out-of-school time, however, there are barriers to capitalizing on this opportunity.

A key concern is the need for ongoing staff development. Staff for out-of-school STEM programs require not only skills and experience in youth development but also technical skills and expertise related to STEM content (Chun & Harris, 2011). Most afterschool staff have little or no content background or teaching experience in STEM. More than three-fourths of afterschool programs do not have a dedicated science person on staff; in fact, most science activities at such programs are conducted by youth workers with little to no science background (Freeman, Dorph, & Chi, 2009). More than half of the staff who lead science activities are not offered any professional development related to these activities.

A variety of obstacles can get in the way of providing quality STEM programming in out-of-school settings. These include:

— Capacity. Many programs offer only limited opportunities for participants to engage in high-quality STEM learning opportunities.

— Commitment. Many providers are reluctant to tackle STEM due to lack of staff buy-in, comfort with science content, and availability of training and materials.

— Sustainability. Stable funding (for supplies as well as ongoing staff development) is needed to ensure continued growth and long-term sustainability of afterschool STEM.

— Perception. The afterschool space is not seen as a vital partner in STEM education.

— Time and attention. STEM programming often must compete with other activities for resources, staff time and student interest (Afterschool Alliance, 2010; Chun & Harris, 2011).

Developing partnerships with organizations and personnel who bring scientific and technical content expertise is a strategy that can help close the STEM gap in out-of-school programs so that more students can gain access to high-interest learning opportunities.

There are challenges to assessing the impact of learning through informal experiences. For example, defining learning goals can be difficult when activities are deliberately learner centered; assessment tools often used in formal education, such as tests, are not appropriate for out-of-school programs (Fenichel & Schweingruber, 2010). Despite these challenges, the promise of out-

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of-school time learning in STEM is drawing increasing interest from researchers, which should yield important insights to inform future program development.

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